THE TIDES IN THE MIDST OF THE PACIFIC OCEAN.

A STUDY BY

ALEXANDER BROWNLIE.

With regard to the general subject of tides, people seem to be impressed with the idea that they ebb and flow with the utmost regularity; that they come and go with mathematical precision; that highest floods occur precisely on the days when the moon is new and full, and *vice versa;* that lowest ebbs occur precisely on the days when the moon is in the 1st and 3d quarters; that when the moon is in the meridian of a place bordering on the sea, then highest floods occur precisely at noon and midnight. They seem to suppose that the movements of the tide are as regular as the movements of the moon itself!

But observation shows that it is not so. On the contrary, everywhere tidal movements form a mesh of irregularities. They are irregular in time-intervals from one high water to the next; from one low water to the next; from high to low, and *vice versa.* There is great irregularity in the daily amount of supply, and great irregularity in the daily distribution of supply, and great irregularity in the speed of supply.

In the present article we make a special study of tide as it has been observed to act right in the midst of the Pacific Ocean, because it is elsewhere assumed that in it lies the source from whence the tides of the whole world come. "In that ocean [the promoters say] the tides have uninterrupted sway." If that is so—if it is true that they have almost uninterrupted sway in that ocean—then we ought to find them working there in harmony with the rules of the science. Of all oceans on the face of the earth, that one ought to furnish the proof to vindicate the truthfulness of the science; or, *per contra*, to show its utter fallacy. In beginning our study we will, in the first place, consider the question of time-intervals.

1. WHAT ARE THE FACTS AS TO TIME-INTERVALS IN THE MIDST OF THE PACIFIC?

At Honolulu, Hawaiian Islands, the intervals of time from one high water to the next vary from 10¼ to 14¾ hours. A range so wide apart shows great irregularity compared with the absolute regularity of the movements of the moon; but, to take a lower

standard of measure, we will take the standard of measure observed in the time-intervals in the Atlantic. For example:

The variation in the range from one high water to the next at

	HRS.	MIN.		HRS.	MIN.
* Charleston, South Carolina, is...	11	52	to	13	00
Sandy Hook, New Jersey......	11	56	to	12	52
St. Johns, Newfoundland......	12	00	to	13	08
Lisbon, Portugal.............	12	10	to	12	55
Rochelle, France..............	12	12	to	12	47
Queenstown, Ireland...........	12	03	to	12	37

The variation shown in the table ranges from 34 minutes to 1 hour 8 minutes; but at Honolulu it is 4½ hours! Now, a variation 300 per cent. greater at Honolulu clearly shows that the driving power there acts with more irregularity than does the driving power in the Atlantic; that the two actions are totally distinct in the matter of time-intervals; and this separate type of tide observed in the *midst* of the North Pacific is also observed upon the *shores*. For example:

The variation in the range from one high water to the next at

	HRS.	MIN.		HRS.	MIN.
San Diego (La Playa) California, is	10	57	to	14	10
San Francisco Entrance (Fort Point)	9	56	to	14	59
Astoria (Columbia River), Oregon.	11	07	to	14	00
Sitka, Alaska..................	10	55	to	14	25
Yokohama (Nishihatoba), Japan..	10	07	to	15	18
Nagasaki, " ..	11	18	to	14	09
Hongkong, China...............	10	28	to	13	34
and in the midst					
Honolulu (Oahu Island), Hawaii..	10	11	to	14	53

But proceeding with our study, we will now pass from the North Pacific to the South Pacific to observe at Apia (Upola Island), Samoan Islands, and there we find exceedingly regular time-intervals; the variation in the range being only 32 minutes—that is, from 12.07 to 12.39. Now, a variation of 32 minutes at Apia makes a very striking contrast when compared with the 4½ hours at Honolulu. The two types are absolutely different from one another; and the contrast is the more striking when we consider the proximity of the two places in the *one* vast expanse; the vastness of

* Authorities: *The Tides*, by Geo. H. Darwin; and *Tide Tables*, by the United States Coast and Geodetic Survey. The figures in our tables in this article are nearly all taken from the U. S. Tables for January 1900.

which is so great that the islands in comparison seem but mere specks of dust holding up their heads in the midst. Yet, in the one there is a great regularity of action, whilst in the other there is a remarkable irregularity of action. In view of these differences, so very remarkable, it is pertinent to ask the questions:

Can the moon cause the irregularity at Honolulu and the regularity at Apia?

If the moon is the power that lifts tide in the Pacific, why are the time-intervals so short at the one and so long at the other?

At the same time we do say that the fact of a difference so enormous clearly throws doubt upon the moon as a lifter of tide; and as clearly points to the inference that we must look elsewhere than to it for the cause of the remarkable differences, because the time-intervals of the moon are regular to the thousandth of a second.

In strange contrast to our finding of remarkable differences in time-intervals stand the unsupported statements in *The Tides* that "Tides are most normal in the Pacific Ocean" (page 161); and that "The tidal forces in it have almost uninterrupted sway"! (page 186).

Our finding shows clearly that the pattern of tides in the North Pacific cannot be taken as the pattern of the tides in the South Pacific; they are not one in pattern, but two, and the two are absolutely distinct from one another in type! Therefore the author of *The Tides* is in error when he speaks of them as normal throughout the Pacific Ocean.

2. The Amount of Tidal Supply in the Midst of the Pacific.

In our second heading we shall consider the question of the daily amount of supply in the midst of the Pacific.

At Apia the average rise is 3 feet per tide.
" Honolulu " " $1\frac{3}{10}$ " "

The variation in the amount of supply shows a difference of 100 per cent. in favor of Apia; that difference is enormous, when we consider the fact that it takes place, not upon a continental shore, where ordinarily the rise varies exceedingly in height from place to place, but upon mere specks in the midst of the Pacific itself.

If our study were political, and the question under consideration one of national tariff, for instance, then it would be pertinent to ask, Why is Honolulu laid under a kind of prohibitory tariff and Apia granted free trade in the article of salt water? It would also be

intensely interesting to know by what means Apia has the "pull" over Honolulu; the fact that it receives a double supply would seem to indicate that the moon has the power of discriminating between the two places! The facts of the case being so, again the inference is quite clear that we must look elsewhere than to the moon for the cause of the differences.

We will next consider the question of the distribution of supply —say the daily distribution during the course of one month. The rules of the science are very clear and precise in regard to this question. For instance, according to them, when the moon is new, or full, it works in perfect unison with the sun; at that time their united forces of attraction lift the water of the ocean three times higher than upon the days when the moon is in 1st and 3d quarters; that when it is in 1st and 3d quarters the power of the lifting forces is reduced by two-thirds, because sun and moon are then struggling against one another; therefore, in the struggle, they are mutually destructive of each other's lifting force.

If the tides in the Pacific are in harmony with these rules, then the greatest distribution of supply must be delivered upon the days when the moon is new or full, and, *per contra*, the smallest distribution of supply upon the days when the moon is in 1st and 3d quarters. That being clear, we will apply the rules to the facts in the case. But, first, an explanation is in order, seeing that we draw our figures from tide tables—and a tide table does not tell us what has been but what is to be. A forecaster can only forecast when he has been supplied *in advance* with *local* tidal data; therefore such forecasts are merely proximate; but the fact remains that they are based upon *actual* observation, otherwise they would be practically worthless to navigators anywhere; because

> if we want to know the rise of tides in a given harbour we must watch the movements at that harbour (*The Tides*, page 194).

Of course, the rule just quoted is only a *recent* amendment, as it were, which has been made to the *original* rules of the science. In short, one cannot make a practical tide table by mathematics only; but it can be done very correctly for any harbour after one has observed its tides for awhile, because tides are *local* in their action, and because the

> knowledge of the (supposed) flow of a (globe) tide-wave can never suffice for accurate prediction of tide anywhere (*The Tides*, page 193).

Precisely so. A very important truth to remember. With that explanation of the most *practical* thing in the science to-day we will now give a table for one month at Apia:

APIA, 171° 44 W. L., JANUARY, 1900.

MOON'S PHASES.	DAY OF MONTH.	HEIGHT OF RISE IN FEET AND TENTHS.	
		1ST FLOOD TIDE.	2ND FLOOD TIDE.
New...............	1	3.0	3.3
	2	3.1	3.4
Perigee............	3	3.0	3.0
(near the earth.)	4	3.0	3.0
Equator............	5	3.0	3 0
	6	3.1	3.0
1st Quarter.........	7	3.1	
	8	3.0	3.1
	9	2 9	3.2
	10	2.9	3.2
	11	3.0	3.0
Farthest north......	12	3.0	3.4
	13	3.1	3.4
	14	3.1	3.4
Full...............	15	3.1	3.3
	16	3.0	3.2
	17	3.0	3.1
	18	2.9	2.9
Apogee—Equator...	19	2.8	2.8
(far from the earth.)	20	2.7	2.6
	21	2.6	2.5
	22	2.5	2.4
3d Quarter.........	23	2.5	
	24	2.3	2.6
	25	2.3	2.7
Farthest South.....	26	2.4	2.8
	27	2.6	3.0
	28	2.8	3.2
	29	3.0	3.4
New...............	30	3.2	3.5
Perigee	31	3.3	3.5

According to the table for Apia, the forecast for the second day is higher than that for the first day; yet on the first day the moon was new the transit occurred towards midnight. Then the supply predicted from time of new moon to first quarter is almost stationary in amount, yet the moon was at perigee on the third day; and the rise at first quarter is about the same as that at new moon and perigee combined! Now, that is not in harmony with the rules; on the contrary, it is just the opposite, because at the

time of first quarter sun and moon are pulling against one another with all their might; therefore, instead of a rise of 3 feet $\frac{1}{10}$th on the seventh day the rise ought to be one foot only! Then, again, the amount predicted for the twelfth day (6 feet 4 for both tides) is precisely the same as that awarded to the fifteenth day—the day when the moon was full. The fact that tide should rise as high and higher than at full moon, for three days ahead of full moon, is positively contrary to the rules. Then, again, from the eighteenth day the supply diminishes, but on the twenty-third day—the day of the third quarter—the rise is 2½ feet. That is all wrong, for the rise ought to have been 1 foot instead of 2½ feet! Lastly, the rise awarded to the thirty-first day exceeds the rise awarded to the thirtieth day; yet on that day the second new moon took place. Furthermore, the moon was at apogee on the nineteenth day; yet, notwithstanding that fact, the predicted rise grows less and less until the twenty-fourth day. For example:

At apogee the rise for both tides amounts to 5 feet 6; whereas on the twenty-fourth the rise for both tides amounts to 4 feet 9, showing a loss of $\frac{7}{10}$ths of one foot five days *after* apogee! From all this it is clear that the practical forecaster did not make his predictions in accordance with the rules, and it is quite clear that there is a small difference between the facts in the case and the fancies of the science. But the question naturally arises, Why did the forecaster cast away all his original rules? Were it a question in theology the correct answer would be, Because his heart is desperately wicked! But seeing that it is only a question in science, our answer is, Because he cannot make a practical table by the original rules! In order to make a practical forecast he must cast away every one of the original rules and abide wholly by the *recent* amendment to them, because it is of more value than all of the original rules combined!

If we want to know *local* tides we must study them *locally*. The study of a so-called globe-travelling wave is absolutely unnecessary; for a knowledge of the science only cannot make one an expert in forecasting practically. That, in substance, is the amendment; but that wholly practical amendment, which is of more value than all the promoter's rules combined, was not discovered by a promoter of the science. On the contrary, it was discovered by a harbourmaster of Liverpool—harbourmaster Hutchinson, the first practical master of the tides. Although he knew nothing of the science, yet he taught the promoters how to make a practical forecast, and he came to be a master because he studied the tides of

his own port for twenty years consecutively! That well-authenticated historical truth in the history of the science proves that this invaluable new light upon the subject was discovered during the time when all the so-called great masters of the fanciful science slumbered and slept. Yet they do not give him true credit for his remarkable discovery to-day; nor did they awake to the value of his discovery until after generations of practical harbourmasters had been in full possession of a lucrative business in the publication of tidal almanacs. The theory was created in the seventeenth century, but the theorists did not learn to become practical until nearly one-third of the nineteenth century had run its course! It was only at the later date when they actually began to study the tides of nature. And yet they were all professors of mathematics!

Having observed the facts regarding the distribution of supply in the midst of the Pacific at Apia, we will next enter into the consideration of the facts regarding the distribution of supply at Honolulu, and present these facts in a table for that port:

HONOLULU, 157° 30′ W. L., JANUARY, 1900.

MOON'S PHASES.	DAY OF MONTH.	HEIGHT OF RISE IN FEET AND TENTHS.		
		FIRST RISE.	SECOND RISE.	SECOND LOW WATER.
New	1	2.2	0.7	—0.2
	2	2.2	0.7	
Perigee.........	3	2.1	0.8	
	4	1.9	0.9	
Equator.........	5	1.7	1.0	
	6	1.4	1.1	
1st Quarter......	7	1.2	1.2	
	8	1.0	1.5	
	9	0.8		
	10	1.7	0.7	
	11	1.9	0.7	
Farthest North...	12	2.0	0.7	
	13	2.1	0.7	
	14	2.1	0.7	
Full............	15	2.1	0.7	
	16	2.0	0.7	
	17	1.9	0.8	
	18	1.8	c.8	
Apogee—Equator.	19	1.6	0.9	
	20	1.5	0.9	
	21	1.3	1.0	
	22	1.1	1.2	

HONOLULU, ETC.—*Continued.*

MOON'S PHASES.	DAY OF MONTH.	HEIGHT OF RISE IN FEET AND TENTHS.		
		FIRST RISE.	SECOND RISE.	SECOND LOW WATER.
3d Quarter.......	23	1.0	1.4	
	24	0.8	1.6	
	25	0.7		
Farthest South...	26	1.8	0.7	
	27	2.0	0.7	
	28	2.1	0.7	
	29	2.1	0.8	
New	30	2.1	0.9	
Perigee..........	31	2.0	1.0	

According to the table for Honolulu (the moon's transit occurred about 11 P.M. on the first day), it is clear that the first day has practically one high water only, yet on that day the moon was new about 11 P.M., and at 9¼ P.M. one of the very lowest of all low tides occurred! It is also clear that the fifteenth day has practically one high water only, yet on that day the moon was full. Upon both of these days the second high water ought to have risen about as high as the first, because at that time both sun and moon were pulling in unison with all their might, but, nevertheless, their united pulling fails completely to lift the second tide anything near as high as the first. Now, the actual lifting in that second tide is a flat contradiction of the science! It is a flat denial of the so-called doctrine of equilibrium, because the natural distribution shows that there is no equality at all between the first and second tides! That remarkable fact is not only disclosed at the time of new and full moon, but almost all through the month. The distribution of supply at Honolulu is so regulated by nature itself that it persistently refuses to be governed by the rules of the science! And yet the author of *The Tides* tells us that tides are normal in the Pacific!

We also observe by the table that the combined lift of the first and second tides, at the time moon was new and full, is only 2 feet 9 and 2 feet 8, respectively; whereas the combined lift at the time of 1st and 3d quarters amounts to 2 feet 4. That is all wrong, for instead of rising 2.4 it ought to have risen only $\frac{9}{10}$ of one foot. In fact, the distribution of supply at Honolulu, when viewed from the standpoint of the rules, is a complete failure, and discloses a tidal

anarchy; for it is quite clear that the tides there are not governed by lunar attraction at all, and the fact of the mathematician's lunar anarchy reigning in the very midst of the Pacific itself clearly absolves us from our allegiance to both Newton and Laplace; and for our ally in this act of open rebellion we claim the weighty support of the greatest living promoter of the science on earth, who said, only recently:

> Both the theories (of Newton and Laplace) must be abandoned as satisfactory explanations of the true conditions.—*The Tides*, page 180.

But we have one more reason still for our act of rebellion; a *cubic foot* of lightest water weighs 62¼ pounds. Now, we are told that during the flow of one very high flood 700,000,000 *cubic yards* of water pass Liverpool. If the moon can lift so enormous a load of water 30 feet or thereby, why can't it pick up a straw? Why can't the moon pick up the feather of a moth's wing at Liverpool? The supposed potency of the moon to lift up enormous loads of water contrasts strangely with the fact of its impotency to raise a straw and so manifest its strength openly!

(*To be continued.*)